Objective: To evaluate the efficacy and safety of laser-assisted in situ keratomileusis (LASIK) in patients with preoperative dry eye.

Methods: We divided the 543 eyes that underwent LASIK into the following 3 groups: eyes with definite dry eye (DE group), with probable dry eye (PDE group), and without dry eye (NDE group). We evaluated visual outcome, dry-eye status, and complications.

Outcome Measures: We compared uncorrected and best-corrected visual acuity, manifest refraction, symptoms, tear function, ocular surface abnormality, complications, corneal sensitivity, endothelial cell count, and patient satisfaction among the groups.

Results: We found no significant differences among the groups in uncorrected and best-corrected visual acuity, manifest refraction, and patient satisfaction. A dry-eye symptom, dryness, was more severe in the DE than the NDE group after LASIK. The mean results of the Schirmer test with anesthesia and tear breakup times were significantly lower and the fluorescein score was higher in the DE than the NDE groups after LASIK. We found no differences in the incidence of complications among the groups. Corneal sensitivity was recovered within 6 months after LASIK in the DE and PDE groups and within 3 months in the NDE group.

Conclusions: The efficacy and safety of LASIK were not affected by preexisting dry eye. However, preexisting dry eye is a risk factor for severe postoperative dry eye with lower tear function, more vital staining of the ocular surface, and more severe symptoms.

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LASER-ASSISTED in situ keratomileusis (LASIK) is an effective procedure to correct refractive error, which induces little wound-healing response and inflammation in the corneal tissue. These factors contribute to stable postoperative refraction, excellent predictability, quick recovery of visual acuity, and no haze formation. However, some patients still experience regression, epithelial ingrowth, or postoperative inflammatory reactions such as diffuse lamellar and microbial keratitis.1,2

In general, good candidates for LASIK should have no ocular and systemic diseases, including active uveitis, keratoconus, and diabetes mellitus, which may adversely affect postoperative wound healing. Although dry eye is not an absolute contraindication for LASIK, compromised tear function and ocular surface may influence the outcome of LASIK. Patients often request refractive surgery owing to contact lens intolerance caused by dry eye. A previous study from our group reported that photorefractive keratectomy could be performed safely on patients with contact lens intolerance due to dry eye as long as reflex tearing was noted.3 Epithelial wound healing, recovery of corneal sensitivity, and visual outcomes of these patients were comparable with previously published data. It is expected that LASIK can be performed safely on patients with dry eye because less epithelial wound-healing response is involved postoperatively compared with photorefractive keratectomy. However, LASIK has its own disadvantages, ie, the corneal nerves are cut by making a flap and recovery time is increased4 when dry eye itself develops.5,6 Thus, we investigated whether the outcome, including visual performance and incidence of complications, was comparable between subjects with and without preoperative dry eye.

Dry eye is a major reason for patients to consider LASIK, and it is a common post-LASIK complication.5,6 Our previous study demonstrated that post-LASIK dry eye develops with compro-
PATIENTS AND METHODS

We enrolled 543 eyes of 290 consecutive patients (mean age, 33.1 years) who underwent LASIK from January 1, 1998, through March 31, 2000, at the Minamiaoyama Eye Clinic, Tokyo, Japan, in this study. These eyes were divided into the following 3 groups on the basis of preoperative dry-eye status: eyes with definite dry eye (DE group; 111 patients and 168 eyes), with probable dry eye (PDE group; 153 patients and 300 eyes), and without dry eye (NDE group; 49 patients and 75 eyes). Dry eye was diagnosed according to the modified criteria established by the Japanese Dry Eye Association. The subcriteria consisted of results of a Schirmer test with anesthesia of no greater than 5 mm, and/or tear breakup time (BUT) of no greater than 5 seconds, and a fluorescein score of at least 1 and/or a rose bengal score of at least 3. Briefly, patients who satisfied both subcriteria were diagnosed as having DE; those who satisfied 1 of 2 subcriteria, PDE. The mean ± SD preoperative refraction in spherical equivalent was -7.24 ± 3.09 diopters (D) in the DE group, -6.82 ± 2.85 D in the PDE group, and -6.5 ± 2.54 D in the NDE group.

For the surgical procedure, a corneal flap was created with a microkeratome (LSK One; Moria, Antony, France; or MK-2000; NIDEK Co, Ltd, Gamagori, Japan), and laser ablation was performed using an excimer laser (Apex-plus; Summit Technology, Walnut Creek, Calif; or EC-5000; NIDEK Co, Ltd). Hyaluronate sodium (Hyalein; Santen Pharmaceutical Co, Ltd, Osaka, Japan) and balanced salt solution (BSS Plus; Alcon Laboratories, Ft Worth, Tex) were frequently applied intraoperatively to prevent dehydration of the ocular surface. Immediately after surgery, high viscous methylcellulose (Lacryvisc; Alcon, Hunenberg, Switzerland) was instilled in the eye and patients were asked to close their eyes and rest for 15 minutes. Low-dose corticosteroids (0.1% fluorometholone [Flunethol; Santen Pharmaceutical Co, Ltd]), antibiotics (ofloxacin [Tarivid; Santen Pharmaceutical Co, Ltd]), and 0.3% hyaluronate sodium eye drops were prescribed 5 times a day. Eyedrop therapy was discontinued at 1 week postoperatively. Hyaluronate sodium eye drops remain on the ocular surface longer than isotonic sodium chloride–based artificial tears and prevent the symptoms and ocular surface damage caused by post-LASIK dry eye.

To evaluate the efficacy of the LASIK correction, uncorrected (UCVA) and best-corrected visual acuity (BCVA) and manifest refraction in the spherical equivalent were examined at 1, 3, and 6 months and 1 year after LASIK. For the dry-eye examination, we assessed dry-eye symptoms and performed a Schirmer test with anesthesia, measurement of tear BUT, and fluorescein and rose bengal staining of the ocular surface. For subjective symptoms of dry eye, dryness was graded by the patients according to the following scale: 0 indicates none; 1, mild; 2, moderate; 3, strong; and 4, very strong. The Schirmer test with anesthesia was performed 5 minutes after instillation of 10 µL of 0.5% fluorescein sodium and 0.4% benoxinate hydrochloride into the conjunctival sac. The Schirmer strip was placed for another 5 minutes, and the length of the wet portion was measured. Vital staining of the ocular surface was performed by instillation of 2 µL of preservative-free mixed-dye solution (1% rose bengal and 1% fluorescein) into the conjunctival sac. Fluorescein staining results were graded from 0 to 3 for the upper, middle, and lower thirds of the cornea. Rose bengal staining results were graded from 0 to 3 for the temporal conjunctiva, cornea, and nasal conjunctiva. Staining was graded by the extent as 0 for negative; 1, scattered minute; 2, moderate spotty; and 3, diffuse blotchy. The tear BUT was measured as the number of seconds between the last complete blink and the first disturbance of the precorneal tear film.

The safety of LASIK was evaluated by incidence of intraoperative (epithelial defect, bleeding, and flap repositioning) and postoperative (recurrent erosion, diffuse lamellar keratitis, microstriae, and epithelial ingrowth) complications, corneal sensitivity, loss of BCVA, and endothelial cell count. Corneal sensitivity was measured with anesthesiometer (Cochet-Bonnet; Luneau Ophthalmologie, Chartres, France) consisting of a nylon filament 60.0 mm long and 0.12 mm in diameter. Patients were asked to look straight ahead and to indicate when they believed that the top of the nylon filament touched the cornea. The measurement was started at 60.0 mm, and the length of the filament was decreased by 5.0-mm increments to increase its rigidity. The corneal sensitivity was defined as the length of the filament that produced a first positive response. We photographed the corneal endothelium using a specular microscope (Konan Medical, Inc, Tokyo), and calculated mean cell density.

We surveyed overall patient satisfaction with the outcome of LASIK, using a grade of 1 for very satisfied; 2, satisfied as expected; 3, not very satisfied; and 4, regretted undergoing LASIK. We performed statistical analysis by means of the t test, Wilcoxon rank sum test, or Kruskal-Wallis test. Values of P < .05 were considered statistically significant.

VISUAL OUTCOME

We found no significant differences among the DE, PDE, and NDE groups in UCVA and BCVA, except at 1 month, when the UCVA was better in the NDE than in the DE group (P = .03). Average postoperative manifest refraction was within ±0.5 D in all groups at all follow-ups. Manifest refractive deviation due to emmetropia was slightly larger in the DE than in the NDE group at 3 months (-0.25 ± 0.76 vs 0.01 ± 0.55 D; P = .01), but we found no differences among the groups at other follow-up points.
The NDE group at all follow-ups after LASIK (Figure 1). However, no statistical difference was found among the groups at any follow-ups. Endothelial cell count was unchanged after LASIK in all groups.

PATIENT SATISFACTION

We found no significant differences in satisfaction among the groups at 3 and 6 months and 1 year after surgery.

Dry eye is a common disease that often causes patients to consider LASIK because of difficulty wearing contact lenses. Among all patients who underwent LASIK in our clinic before March 31, 2000, 35.2% and 41.2% of patients were diagnosed as having DE and PDE, respectively, according to the modified criteria of the Japanese Dry Eye Association. Thus, more than 75% of the patients undergoing LASIK have preoperative dry eye. In the present report, we compared the outcome of LASIK among patients who had DE, PDE, and NDE.

The efficacy of LASIK, determined by means of postoperative UCVA, BCVA, and manifest refraction, was almost comparable in the 3 groups. However, UCVA at 1 month and manifest refraction at 3 months were better in the NDE than in the DE group. We speculate that these differences were due to slight differences in the amount of correction between the groups. The mean refractive correction was -7.20 D in the DE group and -6.47 D in the NDE group (P = .07).

Tear function and ocular surface condition determined by results of the Schirmer test, tear BUT, and rose bengal and fluorescein stainings were more compromised after LASIK in the DE group compared with the NDE group. This finding suggests that patients with preoperative dry eye have more severe post-LASIK dry eye compared with the NDE group. The examination data of patients in the PDE group yielded values that were between those of the DE and NDE groups. A typical dry-eye complaint, dryness, was more marked in the DE group; however, the differences among all groups were not significant at 1 month after LASIK, because this symptom temporarily increased in the NDE group and returned to preoperative levels by the follow-up. In contrast, the subjective score of dryness was more severe and unchanged in the DE group throughout the follow-up. These data may indicate that preoperative dry eye is a risk factor for severe postoperative dry eye.

The precise mechanism for post-LASIK dry eye is not clear. Wilson suggested the term LASIK-induced neurotrophic epitheliopathy (LNE) for a condition of transient ocular surface abnormality, such as punctate keratitis and rose bengal staining of the cornea after LASIK. They speculate that LNE is attributable to interruption of sensory nerve input to the corneal epithelium, which may last for 6 months or longer postoperatively. They also suggest that preexisting dry eye may be a risk factor for LNE. Although tear function is not affected in this condition, LNE and post-LASIK dry eye may be caused by the same mechanism of neurotrophic damage. Our results in this study indicate that preexisting dry eye could

SAFETY

Intraoperative epithelial defect occurred in 4 eyes in the NDE group (P = .2). Fifty-eight eyes (34.5%) in the DE, 78 (26.0%) in the PDE, and 20 (26.7%) in the NDE groups had bleeding from the pannus (P = .5). Flap repositioning was performed immediately after surgery owing to flap folds or dislocated flaps in 4 eyes (2.4%) in the DE, 11 (3.7%) in the PDE, and 2 (2.7%) in the NDE groups (P = .7). We found no significant differences in the incidence of postoperative complications, ie, epithelial ingrowth of 6 eyes (2.0%) in the PDE group, diffuse lamellar keratitis of 1 eye (0.6%) in the DE group, microstriae of 5 eyes (3.0%) in the DE and 8 eyes (2.7%) in PDE groups, and no recurrent corneal erosion.

Loss of BCVA of more than 2 lines was observed in 2 eyes (1.2%) in the DE, 7 (2.3%) in the PDE, and 1 (1.3%) in the NDE groups (P = .4) at 1 year after LASIK.

Corneal sensitivity recovered to preoperative levels within 6 months after LASIK in the DE and PDE groups and within 3 months in the NDE group (Figure 4).
lead to postoperative uncomfortable symptoms caused by dry eye and/or LNE.

Epithelial problems during or after LASIK surgery were of biggest concern in patients with preexisting dry eye. Although we treated some patients who had severe ocular surface damage caused by dry eye with punctal plugs before surgery, most of our patients underwent LASIK without any dry-eye pretreatment except for artificial tears. Epithelial defect, recurrent erosion, and epithelial ingrowth did not preferentially occur in patients with preoperative dry eye. Incidence of other problems, such as flap dislocation, flap folds, microstriae, and diffuse lamellar keratitis was not increased in patients with dry eye. For long-term complications, we found no statistically significant difference in the loss of BCVA between the groups. However, recovery of corneal sensitivity was significantly slower in patients with dry eye. This finding may be explained by dysfunction of tear dynamics in dry eye, because corneal sensitivity is sometimes decreased in these patients. Alternatively, delayed recovery of corneal nerves may be responsible for tear deficiency in these patients. The other possibility is that the difference may be attributable to the amount of corneal tissue ablation, which was increased in the DE group in this study. Kim and Kim reported that greater reduction of corneal sensitivity was observed in cases with deeper ablation.
Our results indicate that the efficacy and safety of LASIK were not affected by preexisting dry-eye status. With the proper ocular surface management, patients with dry eye can be good candidates for LASIK. However, our results also suggest that preexisting dry eye is a risk factor for severe postoperative dry eye with lower tear function, more vital staining of the ocular surface, and more severe dry-eye symptoms until 1 year after LASIK. Patients with dry eye who expect complete resolution of their symptoms after LASIK with removal of contact lenses should be warned that their dry-eye symptoms may persist after LASIK. We have recently found that some patients complain of dry-eye symptoms for more than 1 year after LASIK. The pathogenesis and risk factors of such symptoms are now under investigation.

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